

Conservation of Energy

6-5 The student will demonstrate an understanding of the law of conservation of energy and the properties of energy and work. (Physical Science)

6-5.7 Explain how the design of simple machines (including levers, pulleys, and inclined planes) helps reduce the amount of force required to do work.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 3rd grade (3-5.3), students explained how the motion of an object is affected by the strength of a push or pull and the mass of an object. In 5th grade, students illustrated the affects of force on motion (5-5.1) and explained how a change of force or a change in mass affects the motion of an object (5-5.6). Students have not been introduced to the concept of simple machines in previous grades. Students will further develop the concept of force in 8th grade (8-5.4) and quantitative relationships of work in high school Physical Science (PS-6.4).

It is essential for students to know that a *simple machine* is a device that helps reduce the amount of force required to do work. Work is done when a force (*effort force*) is applied over a distance.

- A simple machine allows the user to apply a smaller force over a larger distance to move an object.
- Simple machines can also change the direction of the force applied.
- If the distance over which the effort force is exerted is increased, the same amount of work can be done with a smaller effort force.
- This is the principle that simple machines use to reduce the amount of effort force needed to do work.

The design of the simple machines can reduce the amount of force required to do work:

Lever

- A *lever* is a rigid bar or board that is free to move around a fixed point called a *fulcrum*.
- The fulcrum may be placed at different locations along the bar.
- A lever can be designed to reduce the amount of force required to lift a weight in two ways: (1) By increasing the distance from the fulcrum to the point where the effort force is applied, or (2) by decreasing the distance the weight is from the fulcrum.
- By increasing the distance the effort force moves relative to the distance the weight moves, a lever can reduce the effort force needed.

Pulley

- A *pulley* has a grooved wheel with a rope running along the groove.
- Pulleys can change the amount and/or the direction of the force applied (*effort force*).
- By arranging the pulleys in such a way as to increase the distance that the effort force moves relative to the distance the weight moves, a pulley can reduce the effort force needed.
- Movable pulleys are used to reduce the effort force.
- A single fixed pulley changes only the direction of the force (you pull down and the weight goes up.)

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Inclined plane

- An *inclined plane* is a sloping surface, like a ramp, that reduces the amount of force required to lift an object.
- An inclined plane can be designed to reduce the force needed to lift a weight in two ways: (1) increase the length of the ramp or (2) decrease the height of the ramp.
- By increasing the distance the effort force moves (length of the ramp) relative to the distance the weight is lifted (height of the ramp), an inclined plane can reduce the effort force needed.

It is not essential for students to know the classes of levers or how to calculate the mechanical advantage of simple machines.

Assessment Guidelines:

The objective of this indicator is to *explain* how the design of simple machines helps reduce the amount of force required to do work; therefore, the primary focus of assessment should be to construct a cause-and-effect model which shows how the design of simple machines (including levers, pulleys, and inclined planes) reduces the effort force or changes its direction. However, appropriate assessments should also require students to *recognize* that simple machines can be designed to reduce the force needed to move an object; *interpret* a diagram showing different designs of the same simple machine to determine which would reduce the amount of force the most based on their designs; or *summarize* the relationship between the design of the simple machine and the reduction in force required to move an object.